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(54) Title of the invention Liquid display apparatus

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Specification

1. Title of the invention

Liquid crystal display apparatus

2. Claim

(1) A liquid display apparatus comprising:

a liquid crystal panel comprising picture elements as a driving unit consisting of many pixels arranged in a matrix form according to a certain array sequence; and

an alternating means for alternating the polarity of the voltage applied to liquid crystal in said array of pixels at a field cycle, characterized in that:

Among red, green, and blue pixels forming the minimum picture element that can represent full color, four, red, green, green, and blue, picture elements are arranged in a rectangle to form a picture element;

said alternating means alternates the polarities of said pixels at a field cycle in the manner that red and green pixel regions and blue and green pixel regions or green and green pixel regions and red and blue pixel regions are applied voltages having the opposite polarities to each other in the same field.

3. Detailed explanation of the invention

[Scope of the invention]

The present invention relates to a liquid crystal display apparatus such as a TFT (Thin Film Transistor) active matrix liquid display, particularly to a method for reducing flicker therein.

[Prior art technology]

Fig.11 shows an equivalent circuit of a liquid crystal display apparatus in the prior art. The figure shows a matrix of liquid crystal cells 1, memory capacitors 2 arranged in parallel to the respective liquid crystal cells 1, and field effect transistors (FET or TFT) 3 connected to one (drain or pixel electrode) of the electrodes of the liquid crystal cells 1.

These three elements form a pixel. The figure further shows plural X electrodes 4 all connected to the input electrodes (source electrodes) of the FETs 3 in each column of the matrix, plural Y electrodes 5 all connected to the gate electrodes of the FETs 3 in each row of the matrix, a scanning circuit 6 for applying scanning pulses to the Y electrodes 5 in sequence, a series/parallel transforming circuit 7 for sampling and holding image signals to transform the image signals for one horizontal scanning line to the same number of parallel image signals as the X electrodes and apply them to the X electrodes 4, a R, G, and B alternating circuits 9 for alternating image signals to supply the alternated image signals to the series/parallel transforming circuit 7, and a common electrode 8 connected to all of the other electrodes of liquid crystal cells.

Fig.13 shows R, G, and B pixel shapes and an array of pixels according to the prior art on the respective liquid crystal cells in Fig.11. In the figure, the solid lines indicate a unit for sample display approximately at the same time (one picture element). This one driving unit (one picture element) consists of R, G, and B, one each, pixels in the prior art.

How this display apparatus is driven is hereafter described.

Assuming Yi is the Y electrodes in the row i, the scanning circuit 6 applies the wave signals that are timed as Y_1 to Y_4 shown in Fig.12 to the Y electrodes 5. The scanning pulses being applied to the gates of the FETs 3, all the FETs 3 in the selected row are turned on and the memory capacitors 2 are charged by the X electrodes 4 via the FETs3 according to the parallel image signals. After the FETs 3 are turned off, the charge stored in the memory capacitors 2 continuously apply to the liquid crystal voltage in accordance with the image signals. Thus, the transmittance of the liquid crystal cells can be controlled by the image signals for display. The driving unit as shown in Fig.13, for example, R, G, and B simultaneous sample display, can be controlled by the way of applying sampling clock to the series/parallel transforming circuit 7.

Here, there is a problem that continuous apply of voltage with the same polarity to liquid crystal shorten the life span thereof. Liquid crystal shows nearly the same transmittance for applied voltages with the opposite polarities. Thus, the alternating circuit 9 is used to alternate the potential of the pixel electrodes in relation to that of the common electrode 8 at the field cycle of NTSC signals (frame cycle on the principle of panel display). Alternated signals are supplied to the series/parallel transforming circuit as image signals.

Then, as for the array of pixels, the horizontal size x_1 and vertical size y_1 of one driving unit as shown in Fig.3 are currently approximately 320 and 240, respectively. Here, the reason for the vertical size being approximately 240 is that the interlaced display of NTSC signals with the vertical size y_1 being 480 leads the update cycle of one pixel to the same as the one frame of NTSC signals (1/30 sec.). This alternating cycle causes problems such as

the life span of liquid crystal and increased flicker.

Therefore, with the vertical size of approximately 240, the first and second fields are overwritten so that 240 interlaced display appears on the panel display with the pixel update cycle of 1 field (1/60 sec.). Thus, the problems above are avoided.

As for flicker in the prior art, as is described above, alternating at the field cycle is used for the sake of the life span of liquid crystal. In practice, liquid crystal does not show exactly the same transmittance for different polarities applied thereto. As a result, the positive and negative screens alternately appear at the field cycle (60Hz) and brightness flicker occurs at the frame cycle (30Hz). In the prior art, for this type of a large screen flicker, positively or negatively driven pixels are divided into the shaded and un-shaded parts to reduce the large screen flicker as is shown in Fig.14. In other words, the whole screen is subject to fluctuation in brightness at 60Hz when no precaution is taken. However, with the precaution described above, the screen repeats fluctuation in brightness in parts, but the fluctuation parts are spread on the screen. Therefore, an average brightness of fluctuation is recognized due to visual LP (low pass) effect. However, when this precaution is taken for an array of pixels according to the prior art, the light-shade stripe pitch is for example 2 x_1 in the case shown in Fig.14. There is a certain limitation on reducing this pitch. Closer look of the screen reduces the LP effect and a so-called line flicker occurs in which the light-shade stripe pattern changes along with the time. When the positively and negatively driven regions are divided as shown in Fig.15, the light-shade pitch is apparently reduced to 2/3 x_1. However, combined with R, G, and B colors, the large 2 x_1 pitch stripe appears and causes a problematic line flicker.

[Problems overcome by the invention]

Having the structure described above, the prior art liquid crystal display apparatus can reduce the large screen flicker, but problematically increases the line flicker.

The present invention is proposed to resolve the problems above and the purpose thereof is to provide a liquid display apparatus that reduces the large screen flicker and line flicker.

[Problem resolution means]

The liquid crystal display apparatus according to the present invention uses a liquid crystal panel in which one picture element consists of R, G, G, and B pixels arranged in a rectangle and the positively and negatively driven pixels on one and the same screen are divided into G·R and G·B or G·G and R·B.

[Efficacy]

In the present invention, one picture element consists of four, R, G, G, and B pixels arranged in a rectangle. The G·R and G·B or G·G and R·B pixel regions are spread and their polarities are controlled so that the vertical spatial margin is effectively used to

reduce light-shade pixel pitch. Furthermore, fluctuations in brightness are converted into fluctuations in color. Taking into account spatial and chronological properties of the vision, the awareness of a flicker can be significantly reduced.

[Embodiment]

An embodiment of the present invention is hereafter described with reference to the drawings.

Figs. 1, 4, and 6 show arrays of pixels where four, R, G, G, and B, pixels form a picture element according to an embodiment of the present invention. In Fig.1, the solid lines indicate a picture element. The horizontal and vertical sizes x_1 and y_1 in the prior art correspond to the horizontal and vertical sizes indicated by the solid lines in Fig.1.

With the array of pixels above, the G-R and G-B or G-G and R-B regions are defined to alternate the polarities so that they have the opposite polarities. For example, the array of pixels shown in Fig.1 is possibly divided into the patterns shown in Figs. 2 and 3; the array in Fig.4, the pattern in Fig.5; and the array in Fig.6, the patterns in Figs. 7 and 8. The shaded and un-shaded regions in the figures have the polarities alternated oppositely. The respective pixels also have the polarity alternated at the field cycle. In all the figures, the shaded and un-shaded regions consist of G-R and G-B or G-G and R-B pixels. Similar circuits to the prior art in Fig.11 can be used except for the R, G, and B alternating circuit 9, which will be modified on the positive and negative control according to the patterns described above.

Effect of the present invention in reducing flicker is hereafter described.

One picture element consisting of four, R, G, G, and B, pixels arranged in a rectangle allows effective use of the vertical spatial margin as is described for the prior art structure. Particularly, the vertical size of a pixel is $y_1/2$, which is half the prior art's. One picture element is divided into two in the vertical direction; thus, two rows (two pixel lines) are simultaneously driven. As for the horizontal pixel size, one picture element has a width of x_1 so that one picture element has the same size as that of the prior art (in order to achieve the same horizontal resolution). One pixel has a horizontal width of $x_1/2$, which is slightly larger than $x_1/3$ in the prior art. However, the same horizontal pixel size as in the prior art is available in the process of producing a panel in practice. With the panel size being considered to be fixed, the horizontal resolution that is 1.5 times larger than that of the prior art can be achieved.

Flicker is hereafter described. The light-shade stripe pattern appears at a pitch of 2 x_1 in the example of Fig.14 when taking a closer look in the prior art. This stripe pattern is subject to chronological changes and recognized as line flicker. However, in the present invention, the stripe pattern appears at a pitch of x_1 or y_1 as shown in Figs. 2, 3, 5, 7, and 8. x_1 is nearly equal to y_1 in actual panels for balanced horizontal and vertical resolutions.

Thus, the pitch of this stripe pattern is half the prior art's.

Fig.9 shows the spatial – relative sensitivity property of human vision cited from a TV handbook. In the figure, the abscissa shows cpd (cycle / degree) and the ordinate shows the relative sensitivity. Approximately 10 times larger intervals are necessary for the color differences, such as read – green and yellow – blue, compared to light-shade as is seen from the figure. The pitch, which is half the prior art's as is described above, is substantially small enough for color blending.

In the present invention, pixels are divided into G·R (= yellow) and G·B (= cyan) or G·G (= green) and R·B (=magenta) regions for alternating. Thus, for example, assuming that the shaded part is highly bright in the case of Fig.7, the intervals between R, G, and B are satisfactory for blending and, therefore, G·B and G·R are respectively blended to present cyan and yellow stripes at a pitch of X_1. In this case, as is shown in Fig.9, the lower limit of recognizable pitch for color difference is significantly lower than that for brightness difference. Stripes having the same pitch as in the prior art are hardly recognized as spatial stripes.

In the prior case shown in Fig.15, for example, if the shaded part is highly bright, magenta and green stripes are juxtaposed to each other at a pitch of 2 x_1 according to the process above. The magenta and green stripes have highly visible compared to the cyan and yellow stripes as is shown in Fig.9. The horizontal pitch can be reduced for the same horizontal width of pixels in the prior art. Hence, the present invention achieves a larger LP effect.

Finally, chronological fluctuations in brightness are described. The lower limit at which flicker is not recognized by human eye in the course of chronological fluctuations in brightness is approximately 50 to 60 Hz. However, liquid crystal TVs are subject to fluctuations in brightness at approximately 30Hz, which can be recognized. The present invention has the same fluctuation frequency of 30Hz as in the prior art. However, the fluctuation components consist of alternate cyan and magenta stripes. Visually, this color changes are less recognizable than fluctuation in brightness (for example, National Television Conference, p11, 1973 (Sakata, Isono) reported that the maximum sensible frequency is 3Hz (10 to 20 Hz for brightness)). Consequently, flicker is reduced.

Needless to say, the arrays of pixels that form a picture element of the embodiment shown in Figs. 1, 4, and 6 can be replaced with those shown in Fig.10 to achieve the same effect.

[Efficacy of the invention]

As is described above, in the present invention, among red, green, and blue pixels forming the minimum picture element that can represent full color, four, red, green, green, and blue, picture elements are arranged in a rectangle to form a picture element. The

polarities of the pixels are alternated at a field cycle in the manner that red and green pixel regions and blue and green pixel regions or green and green pixel regions and red and blue pixel regions are applied voltages having the opposite polarities to each other in the same field. This causes the flicker with stripes of alternate different colors, cyan and yellow, as well as with a small spatial pitch. In this way, visual LP effect, not only spatial but also chronological, can be enhanced, significantly reducing line flicker and large screen flicker.

4. Brief explanation of the drawings

Figs.1, 4 and 6 are illustrations to show arrays of pixels of the liquid crystal display apparatus of the present invention. Figs. 2, 3, 5, 7, and 8 are illustrations to show the divisions of pixels that are positively and negatively driven of the present invention. Fig.9 is a graphical representation of the spatial – relative sensitivity property of human vision. Fig.10 is an illustration to show other exemplary structures of one picture element (one driving unit) of the arrays of pixels in Figs. 1, 4, and 6. Fig.11 is an illustration of an equivalent circuit of a liquid crystal display apparatus. Fig.12 is an illustration to explain the operation of the scanning circuit of Fig.11. Fig.13 is an illustration to show an array of pixels in the prior art. Figs. 14 and 15 are illustrations to show the way to avoid flicker in the prior art.

In the figures shown are liquid crystal cell 1, memory capacitor 2, FET 3, X electrode 4, Y electrode 5, scanning circuit 6, series parallel transforming circuit 7, common electrode 8, and R, G, and B alternating circuit 9.

In the figures, the same reference numbers indicate the same or corresponding parts.

Representative Ken-ichi Hayase

Fig.9

Relative sensitivity (dB), light-shade, red – green, yellow – blue

Fig.11

6 scanning circuit

7 series parallel transforming circuit

1: liquid crystal cell

2: memory capacitor

3: FET

4: X electrode

5: Y electrode

8: common electrode

9: R, G, B alternating circuit

Amendment (voluntary)

TO: Commissioner of the Japan Patent Office

1. Case

   Japanese Laid-Open Patent Application H01-215212

2. Title of the invention

   Liquid crystal display apparatus

3. Ammender

   Relationship to the case Patent Applicant

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5. Object of amendment

   Detailed explanation of the invention and Brief explanation of the drawings in the specification

6. Contents of Amendment

   (1) replace "nani you ni to suru" in the specification, page 9, line 7 with "naru you ni suru." (translator's note: typo)

   (2) replace "spatial – relative sensitivity" in the same, page 11, line 11 with "spatial frequency – relative sensitivity."